STEM Teachers in Professional Learning Communities: A Knowledge Synthesis

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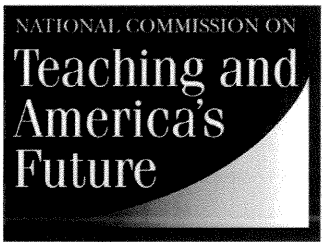

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Overview of Key Findings

Before highlighting the findings, we review three aspects of our study that are important for understanding these findings. First, the charge in this study examined professional learning communities (PLCs) whose membership and focus was exclusively on one or more subjects of science, technology, engineering and/or mathematics (STEM); or, if other subjects also were included, the STEM aspects were explicitly addressed. Therefore, **we did not review the PLC literature as a whole.**

However, we raised the question "Are STEM PLCs a different phenomenon?" with both our online panel and advisory board, since many of these individuals also have general experience with PLCs. They indicated that **what we found for STEM teaching is generally confirmed by their experience with the PLC literature at large.** Thus, our report generally contextualizes the PLC discussion specifically for STEM rather than making a case that STEM PLCs are a very different enterprise; but there are a few aspects that do seem unique to STEM PLCs. A valuable area for future analysis would be a formal explicit comparison of PLCs in STEM fields versus PLCs more broadly.

Second, while the topic of Professional Learning Communities is under widespread, extensive discussion among both researchers and practitioners, the range of PLC definitions is quite wide, to put it mildly. Our task was not to create an official definition of a PLC. Nonetheless, we maintain that it is important for the field that **each of the components in the term "Professional Learning Community" should be fulfilled in order to regard some activity as a PLC: *professional* – engaging educators in the development of their professional practice; *learning* – focused on both the learning of the educators and the learning of their students; and *community* – which requires common vision, goals, purpose, and a shared sense of trust as well as collaborative work.** Beyond this stance, our definition of PLCs for this study generally was meant to be inclusive rather than restrictive: involving three or more teachers, including a STEM focus, and being a sustained enterprise rather than a one-shot or very limited-time endeavor; generally, our STEM focus precluded consideration of enterprises where whole schools are operating as PLCs.

Third, **this "knowledge synthesis" was enhanced by beginning with a traditional literature review but expanding it to include additional sources of knowledge that are important for understanding this topic at this moment in time.** Thus our sources also include published expert advice and opinions/policy, published descriptions of models for STEM PLCs and their "lessons learned," and reactions and advice from a panel of people having expertise on designing and leading STEM PLCs. Because much of the work of PLCs in STEM is relatively recent (e.g., research reports are only now being produced as a result of Math Science Partnerships funded by NSF in recent years), the volume of empirical research studies is growing quickly each year but as of now it is evolving rather than mature. While our other knowledge sources may not meet the "gold standard" of empirical research, we found that they generally were consistent with findings emerging from the empirical studies and were important for elaborating them.

We group the most notable results of our knowledge synthesis by addressing four questions:

1. **What do We Know about STEM PLCs**? What are the findings? Some findings cut across all the kinds of knowledge sources that we amassed, while others are more specific to particular knowledge sources used in our project.

2. **How Well do We Know it?** How strong is the knowledge that we found?

3. **What is the Source of this Knowledge?** Describes the landscape of available knowledge.

4. **What Else Might We Want to Know?** What are the most notable gaps in the available knowledge

What Do We Know about STEM PLCs?

They were universally recommended

- Published comments or policy statements about STEM PLCs support their use to an amazing extent. Unlike most topics in education, there was no opposition; however, there were important cautions about being clear and substantial rather than superficial in defining and implementing them. All other knowledge sources also recommended their use (e.g., the conclusion sections of research articles).

There are key elements to consider in designing STEM PLCs

- In designing STEM PLCs, close attention needs to be paid to many aspects related to time and pacing. There can be issues in how to evolve over time a stronger and stronger group focus on mathematics and science content knowledge as well as on pedagogical content knowledge (PCK), since public discussion of them might be very foreign and threatening given our historical practice of teaching in isolation. The relationship between specific desired PLC purposes and the available conditions for meeting them must be wisely factored into deciding how much time to meet and how often, and what's happening during the times in-between.
- Comprising PLCs with teachers from multiple subjects (even limited to mathematics and science) can limit the depth or effectiveness of work on content knowledge or PCK.
- Having protocols for STEM PLC group functioning is important, as is building in protocols for examining students' work. However, design and use of protocols must be carefully considered and monitored (e.g., the protocol can become the end instead of the means).
- Having facilitation, administrator support and trust-building are crucial. Regarding facilitation, there are many kinds but all of them require some professional development because facilitating adult learning is different than facilitating student learning.

We found positive changes in STEM teachers.

- Participation in PLCs can successfully engage teachers in discussion about content knowledge or knowledge about how to teach it (pedagogical content knowledge or PCK), positively impacting their understanding of or preparedness to teach content, or attitudes toward teaching methods.
- Participation in PLCs increased teachers' deliberation about students' mathematics or science thinking.

We found positive changes in STEM teachers' instruction.

- Participating teachers' practices often become more "reform-oriented" (although this term was often imprecisely defined and/or the reform practices were not clearly defined).
- Studies reported increased teacher instructional attention to students' reasoning and understanding, and use of more diverse modes of engaging student problem-solving.

We found a small number of studies showing positive effects on mathematics student learning and achievement.

- Only a few studies were available, and all of them investigated student impacts in mathematics; this is likely, in part, because there commonly are more assessment data available in mathematics.
- Overall, this small set of studies gives some existence proof that teacher participation in a mathematics PLC can lead to an enhancement in what their students learn. The case cannot yet be made from these studies that sufficient evidence exists to clearly link results on formal student assessments to teacher participation in PLCs, but the positive trend is noteworthy. The PLC literature at large (versus specific to STEM PLCs) that examines the relationship between student achievement and teacher PLCs is similarly emergent rather than definitive (Vescio, Ross & Adams, 2008).

What is the Appropriate Definition of a PLC?

Some online panelists were concerned about our definition of a PLC. We recalled that, in searching for research and knowledge sources about PLCs we used an expansive definition: PLCs involve three or more participants, they include mathematics and/or science teachers, they involve either just teachers or teachers plus other participants, the PLC participants are engaged in joint learning or work, and the PLCs address a wide range of aspects of teaching. The panelists encouraged us to include student learning in the definition because PLCs should focus on student work and learning.

One panelists discussed DuFour's distinction between "collaboration vs. co-blabaration," meaning that, when a PLC is not focused on student learning, it's just a lot of talking and sharing. The group may not be using data that confirm that what they are doing is working, so they continue to do it anyway. There was also discussion of the "continuum of collaboration," beginning with breaking the isolation and moving toward deeper conversations during which teachers develop "habits of mind" and reflect on the impact of instruction on student learning. PLCs were described a "dynamic"; there is a continuous evolution. One panelist noted that when teachers rated themselves on the PLC continuum, the more involved the teachers were, the more accurately they rated themselves. She noted that teachers who had engaged in authentic PLCs were more realistic while, ironically, those who were not trained thought they were doing better!

Many of the research articles that came up during our search were about lesson study groups, based on the Japanese model of lesson study. The online panel responded to a question about whether or not they believe that lesson study constitutes a PLC. The consensus was that, while lesson study can be part of a PLC, it is not automatically a PLC in its own right. They commented on the fact that lesson study groups are typically focused on a particular lesson or series of lessons, while PLCs can have a much larger goal or focus. Additionally, lesson study does not focus on shared goals or vision, which all maintained is key to an effective PLC.

When asked about PLCs in preservice education, the panelists generally agreed that engaging student teachers in PLCs in the school where they are assigned can be a very positive experience. One panelist reported that she worked with student teachers who experienced PLCs in the schools where they were assigned for student teaching, but then hired in schools that did not have PLCs – they all requested to return to the PLC schools. One panelist suggested that

"working in PLCs" as a consideration for placement of student teachers in schools might be a good policy. "They would develop the skills to know when they are in a PLC with the high level of conversation that involves, versus "meeting talk."

What are the Differences Between STEM PLCs and PLCs in Other Content Areas?

We probed the online panel about what they saw as the differences between a STEM-focused PLC and a general PLC. In the case of STEM PLCs, the dialogue of the team members clearly focuses particularly on student learning in STEM areas. The panelists felt that the focus is more likely to be on the development of content knowledge than is the case in a general PLC. STEM teams are more likely to identify instructional strategies to engage students in STEM issues and to discuss how what the students are learning relates to their lives and future careers.

Several panelists felt that math and science lend themselves to PLC work more than social studies or language arts, due to the scaffolding of skills found in math and science. (Another panelist suggested, however, that most disciplines scaffold learning from one stage and grade level to the next). While one panelist working in high schools and middle schools had found it easier to implement PLCs in science than in math, finding it harder to build a dialogue around math, others disagreed, suggesting that math has more of an obvious sequencing for collaboration, which can become a framework for discussion. Furthermore, there is an increased pressure for improvement in math teaching due to NCLB testing requirements. However, others felt that science teachers have common tools (i.e., inquiry methods) that can be a vehicle for collaboration. Science teachers are also used to working together in labs and on lab schedules, so the transition to collaborating on student data and professional learning might be easier.

Most panelists agreed that for PLCs to work across content areas would likely be more difficult than PLCs working within one content area. Those panelists with experience working across subjects felt that finding points where the curricula cross was a challenge and can feel forced (unless they were working on an interdisciplinary course). However, one panelist suggested that a good facilitator can help teachers see the connections across content areas in such skills as accessing and synthesizing information from charts, graphs, diagrams, maps, etc. The panelists suggested that making connections between math and science is often a primary motivator for STEM PLCs. As one said, "In order to better integrate content and inquiry between disciples of science (physics, chemistry, biology, Earth science), PLCs are necessary. Taken to another level, to infuse math or engineering (design and process skills), PLCs are even more important in order to blend content and process."

What are Key Factors for Effective PLCs?

The panelists laid out what they thought were some of the most important factors for implementing and maintaining an effective PLC. Their views closely paralleled recommendations found in our Type 1, 2 and 3 knowledge sources and the general models described in the Type 5 knowledge souce discussion below. Despite their having worked in and with varying levels and types of PLCs, their agreement around key factors for PLCs to be effective was notable. Among these factors are:

1. The first factor, which they cited as the most important, is to establish a common vision, mission and goal for the PLC. All team members must understand and buy-in not only to the importance of their PLC, but also what the goals for their PLC are.
2. It is imperative that teachers draw the connection between their teaching and student achievement. Stakeholders must also have an understanding of what work is really involved to get to improved student achievement.
3. Members of the community must be trained on the processes and feedback loops of PLC work. The community must also work together to establish group norms, expectations and processes so that they are accountable to each other and the school leadership.
4. One panelist suggested that there be special attention paid to the protocols for engaging in student data analysis and assessment.
5. Another suggested that in her research of high school PLCs, with varying formats and activities, the key to success was the principal. "The key to pushing the conversation to student learning and instruction was the relationship to the principal. In PLCs where the principal attends sessions regularly there was more substance to the discussion. Those without a clear leader lacked structure." Others confirmed that a good leader is critical at all levels of schooling, not just high school.
6. Continuity matters as well. As one panelist noted, "In a PLC with lots of turnover (e.g., with many Teach for America teachers) the PLC work could not advance because the culture kept changing and they didn't develop a common language."

Is there a Minimum Threshold of Activity for PLCs to be Effective?

We asked the panelists if there was a minimal threshold of collaborative activity (e.g., size of group, frequency of meetings and amount of time spent together) to make a PLC worth the effort. Conversely, is there a point when it is detrimental to engage in PLC work if it is not done "right"? The panelists had no set guidance for our "minimal threshold" question. One panelist suggested that working with large groups, while not as effective as small groups, is possible but requires a very skilled facilitator and often means breaking a group into smaller groups – referred to as "professional learning teams" with the whole school as the "learning community." Most felt that smaller groups lead to more dynamic conversation, with all teachers' voices heard.

In general, however, although we probed this question in several ways, the panelists usually reverted back to discussing what they thought were the key factors for success. One panelist gave four factors that must be in place for minimal effectiveness: 1) commitment to connecting professional learning and student learning, 2) agreement on why the group meets, 3) structures in place to ensure continuity, and 4) archiving/documentation of teacher learning and the impact on student learning. Another suggested that their minimum requirements for success were developing inquiry questions, establishing group norms, setting SMART (Specific, Measurable, Attainable, Rigorous and Time Bound) goals, using common formative assessments, using common corrective instructional strategies, applying data analysis, and maintaining a shared vision and goals (these too reflect the elements found throughout the research reviews).

Several panelists pointed out that there is a continuum of collaboration which moves from discussion of activities and instructional practice to a deeper analysis of the relationship between

instructional strategies used and student learning and data. While the focus might be on content early in their collaboration, it will deepen to student learning as the PLC participants grow comfortable with each other. However, they felt that PLCs are most effective when they move to discussing evidence of student learning (student class work, benchmark data and achievement data) as soon as possible. One panelist suggested that bringing in student work from another class (i.e., not that of the teachers in the PLC) can be used to open the discussion with less sense of threat to the teachers and can accelerate the process of building trust. One panelist described using pre-tests as the student work under discussion. "The teacher had not yet influenced the learning being tested, so it was 'safer' to share this with colleagues in the PLC." All panelists agreed that any ongoing collaboration is better than traditional one-shot professional development workshops.

If there is a Good PLC in a School, does this Negate the Need for Other Professional Development?

The consensus was that professional development should support what comes from the work of the PLC, not exist as a separate structure. In an ideal setting, professional development will be designed for teachers as a result of needs they encounter as they meet in PLCs. For example, teachers may find they need training in the analysis of student data or in how best to use student work samples in a PLC. They may need additional training in the development of formative assessment techniques that provide them with information about how well students are mastering the expectations in the standards and curriculum they are teaching. One area of need seen in many PLCs is helping teachers adjust instruction to meet the needs of diverse learners and determine next steps when they discover that not all students have acquired the knowledge and skills from a particular lesson. When teachers have learned new ideas or refined their skills during a professional development session, they can then discuss the implementation of the knowledge and skills as they meet in their PLC, thus providing immediate follow-up from a learning experience and increasing the odds that the new learning will be used effectively.

What is the Role of the Facilitator?

It was suggested that PLCs are enhanced when the role of a facilitator is included in the design of the PLC. The panel discussed whether the facilitator could be a member of the team or if they had to be an outsider. While a peer facilitator may have some trust established within the group, it can become uncomfortable if it is necessary to deal with a group member who is not fully participating. Then the facilitator is put in the difficult situation of being both a peer and a superior. Some panelists felt it was important for the facilitator to be able to remain neutral and not have to participate in the PLC.

The key role of the facilitator is to ensure that the group stays on track, working toward their shared goal. One panelist felt that the facilitator should ensure that everyone is in the same boat because "people don't shoot holes into boats they are in." The facilitator should push the conversation when necessary to ensure the process continues and should keep the discourse focused on student achievement and teacher learning. Facilitators set the tone for the group. They communicate clear expectations, build capacity for participation, and monitor and reflect on practice.

Panelists also felt that a facilitator with content expertise was more beneficial than one without content knowledge in the field. A content knowledgeable facilitator can push the conversation and add his or her own content expertise. Although a "generic" facilitator can discuss pedagogy or data analysis in general, this jeopardizes the group moving to greater depth content wise. However it is important that the facilitator not be seen as the only expert, as the teachers are all contributors whose expertise must be acknowledged and valued.

The panelists agreed that, regardless of their content knowledge, facilitators require training in facilitation, coaching and data analysis. The training should be followed-up over time rather than being a one-time occurrence. It is important for a facilitator to have an understanding of the realities that teachers face (e.g., standards, pacing guides, etc.) so that the group can take those into account when discussing their goals and plans.

Should PLCs be Voluntary or Mandatory?

The panelists felt there would be much less tension in a voluntary PLC; however it would be easier to put the support structures in place when the district initiates the idea of setting up the PLC. One described voluntary PLCs as nothing more than "collaboration without a formula." A district-wide initiative requires consensus from the top level about what implementation looks like, and that needs to be communicated to the school administrators and teachers. Whether the PLC is voluntary or mandatory, every stakeholder must be prepared for PLC work; otherwise the time spent in PLC meetings turns into conversation time without direction, making it feel like a burden rather than an effective process. The district must work toward supporting the buy-in of all stakeholders; especially in circumstances where PLC participation is mandatory. This includes everyone from Boards of Education down to the parents. As one panelist said, "When PLCs are mandated, there needs to be a foundation set as well as an understanding by the staff that fits the culture of a school district, or chances for success are less likely. Parents need to be informed and also agree with the district philosophy that if instructional time is taken from the school day it is in the benefit of their children." This panelist maintained that, without this buy-in, parents will want the PLCs to meet after school rather than on school time.

How does School Leadership Impact PLCs?

Panelists described a school administrator's main role in PLCs as setting the tone in the school and in PLC groups. The principal's role is to set expectations that being a member of a PLC is an essential part of the work of teachers and to establish a culture of collaboration within the school. Leadership at all levels needs an understanding of how PLCs work so that they can determine how they can best support PLC work. They set the context and structure for collaboration: time and space to collaborate, support for PLCs in the form of ongoing professional development when needed, and the ongoing monitoring and data gathering to determine the effectiveness of PLCs.

Panelists agreed that some level of participation of the principals in the teams is needed to provide further support (e.g., outside help, more time, motivation, etc.). However, panelists felt it is inappropriate for the principal to serve as facilitator; there is a balance that each principal must find between participating and allowing their teachers some autonomy. The principals must support teachers in allowing them to direct their own professional learning. One panelist stated that the principals must work as the "lead teacher" since teachers are adult learners that need support to reach their full PLC potential.

Principals must also do some level of monitoring to ensure that real PLC work is happening. They may participate on occasion, monitor agendas and meeting notes, or have presentations from some of the team members. Some researchers have developed matrices to measure both the level of implementation and the effectiveness of PLCs; these can be useful tools for principals to use with their teams. As one panelist said, "As an administrator, I don't know how you could claim to have a successful PLC school if the administrator isn't highly involved. PLCs give teachers the power to direct their own learning and development, but there is a difference between power and autonomy.... Teachers will say they don't want complete autonomy – they want administrators' support and resources.... We can't be effective in support if we don't know what is going on."

What is the Role of the Internet in PLCs?

Several panelists have done extensive work in online communities; their thoughts are highlighted here. They noted that online communities are different than face-to-face communities because they are not space and time limited. Communities can access each other anytime and anyplace. However they must also take the initiative to engage. Participants can also self-select to participate in online communities that address their specific needs/areas of expertise. Online communities often feature more discussion of pedagogical content knowledge (application of content) as opposed to student work or data, because in many online PLCs there are no common students or classroom settings. Their discussions are then about adapting content to a teachers' context. Finally, an online facilitator is more likely to be serving as an expert than as a peer facilitator. The online facilitator should have a lot of answers, or know where to go for the right answers. He or she may be the most active participant in the community and needs enough knowledge to keep the conversations both flowing and helpful.

In addition to strictly online communities, the panel felt that technology is now seen as a great support for face-to-face communities as well. An online platform can make it possible for the conversation to continue after and between meetings. It can also function as a central repository for information and other collaborative materials.